

Structural Integrity of RC Columns Wrapped with FRP Sheet Subjected to Various Environmental Conditions Including Corrosion

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Wrapping a reinforced concrete (RC) column with fiber reinforced polymer (FRP) composite materials has emerged as an efficient alternative to steel jacketing because of their inherent advantages such as unique design flexibility, ease in manufacturing, fabrication, handling and installation, non-corrosive nature, and excellent strength-to-weight ratio. Thus, there has been a rapid growth in their use for the repair/rehabilitation of structurally deficient RC columns. The short-term performance of RC columns wrapped with FRP composite materials has been widely investigated. However, research studies and knowledge on the long-term performance are limited. The objective of this study was to evaluate the effects of various environmental conditions on the long-term behavior of RC columns wrapped with FRP sheets.

This study included three main tasks; experimental program, development of analytical model, and development of design guidelines for RC columns wrapped with FRP sheets. The experimental program comprised two parts; ambient environmental effect tests and corrosion tests. The environmental conditions considered in the ambient environmental tests included (1) freeze-thaw cycles, (2) high-temperature cycles, (3) high-humidity cycles, (4) ultraviolet (UV) radiation, and (5) saline solution. The corrosion tests dealt with the corrosion of steel reinforcement in RC columns wrapped with FRP sheets including the effect of FRP wrapping as a repair technique for RC columns under severe corrosion state. Two different scales of RC columns were used in this experimental program: (1) small-scale RC columns for the extensive parametric study and development of design guidelines and (2) mid-scale RC columns for the evaluation and calibration of the proposed design guidelines. RC columns were wrapped with carbon fiber reinforced polymer (CFRP) sheets and glass fiber reinforced polymer (GFRP) sheets and conditioned under the environmental conditions listed above. After the environmental conditioning, uni-axial compression tests were conducted in order to evaluate the mechanical properties, such as column capacity, stiffness, and ductility.

The test results showed that the mechanical properties were affected by the environmental conditioning and the corrosion of steel reinforcement, and the effects varied with the types of environmental conditions. Based on the results, improved design guidelines for the RC columns wrapped with FRP sheets were proposed.

The design guidelines included reduction factors to account for the effects of various environmental conditions to be used with the design equations proposed to determine the axial compression capacity of RC columns wrapped with FRP sheets. The proposed design guidelines also included an analytical model to predict the axial stress - axial strain relationship of concrete wrapped with FRP sheets. The performance of the proposed design guidelines were validated through a comparative study with the test results of mid-scale RC columns, and other tests available in the literature.

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